The Clinical Application of Minimally Invasive Coronectomy with Piezosurgery

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Objective:To evaluate the clinical feasibility of minimally invasive coronectomy with piezosurgery for the impacted mandibular third molar,which is in contact with the inferior alveolar nerve.

Methods:Minimally invasive coronectomy was carried out with piezosurgery to remove the crown while the roots retained in the alveolar bone ,then the operation time and the complications of minimally invasive coronectomy and coronectomy were compared.Six months after the operation,curved tomogarphy and CBCT were reviewed to evaluate and measure the displacement distance of the root, and remove the root in the second minimally invasive surgery.

Results:There was no significant difference in operation time between the two groups.Intraoperative complications and inferior alveolar nerve injury occurred in neither group.The incidence of moderate severe swelling and mouth-opening limitation was significantly lower in the minimally invasive coronectomy group than in the coronectomy group.There was no significant difference in the incidence of postoperative bleeding,nerve injury,moderate severe pain,dry socket disease and subcutaneous emphysema between the two groups.The roots were all displaced forward and upward six months after operation,The average displacement distance was 2.58mm and 2.62mm,respectively.No inferior alveolar nerve injury occurred in the second minimally invasive extraction of root.

Conclusion:The incidence of inferior alveolar nerve injury after minimally invasive coronectomy with piezosurgery is low,and the postoperative complications (swelling and mouth-opening limitation)are significantly reduced,which makes it worth clinical promoting.

Key words:piezosurgery;minimally invasive;Coronectomy;inferior alveolar nerve injuries

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The main postoperative complication of the impacted mandibular third molars which were close to or compressed the inferior alveolar neural tube in the apical segment was inferior alveolar nerve injuries (IANI) [1]. For the impacted mandibular third molars that must be removed in the clinical treatment, IANI often brings great pain to patients after surgery, and also causes unnecessary medical disputes to oral and maxillofacial surgeons.

In order to avoid the occurrence of IANI, scholars at home and abroad have tried different methods and gained good achievement. At present, there are mainly orthodontic traction and extirpation [2], Coronectomy [3]. Orthodontic traction and extirpation is seldom carried out in clinical practice due to the complicated operation process, more frequent visits, higher treatment cost and greater trauma, etc. [4].

Ekuyer et al. [5] proposed the idea of " Coronectomy " for the first time. Coronectomy refers to the method of removing only the crown and retaining the root in the alveolar bone for the impacted mandibular third molars, so as to avoid the impact of direct removal of affected teeth [3, 6]. This method can keep the root of the tooth in the alveolar bone for a long time and the second operation should be avoided. However, after long-term observation, postoperative root displacement away from the neural tube was inevitable [7]. When the root "erupts" again, the root is far away from the inferior alveolar neural tube, and there is no risk of IANI to extracte the root [8].

1. Clinical data

1.1 General information

The subjects were 60 patients who underwent minimally invasive crown-cutting and root retention in the Department of Oral and Maxillofacial Surgery, Jiading District Institute of Dental Disease Prevention and Control in Shanghai from November 2016 to September 2018. Among them, there were 30 patients (14 males, 16 females) in the minimally invasive coronectomy group, aged 21~35 years, average 27.1 years. The crown amputation group were 30 patients (15 males, 15 females), average 26.9 years. Inclusion criteria: a. Curved sectional films and CBCT films showed no caries or apical inflammation in impacted mandibular third molars, complete root development, and high risk factors such as contact and compression between root and inferior alveolar neural tube; b. Patients without tooth extraction contraindication and informed consent to participate in this study. The operative time, intraoperative and postoperative complications were recorded. Half a year after the surgery, curved radiographs and CBCT were taken to evaluate the displacement of the root and measure the displacement distance, and the root was extracted in the second stage of minimally invasive surgery.

1.2 Research Methods

1.2.1 Preoperative examination

To understand the medical history and the patient's general condition, improve the preoperative examination (curved tomography, CBCT, laboratory examination, etc.), formulate the surgical plan, and sign the informed consent for surgery.

1.2.2 Surgical methods.

The procedure of minimally invasive Coronectomy (Figure 1) : open and turn flap: a. Distal angular incision of the second mandibular molar (angular flap). According to the condition of the affected tooth, the angular incision should be avoided involved in the vestibular groove as far as possible, so as to expose the buccal bone of the third molar. b. The third molar was distally incised to the neck, or it was better to expose the bone above the neck; Deboning: Piezosurgery is used to remove the bone around the crown to the enamel cementum. Crown removal: turbine (assistant

with spraying saline) from buckling to lingual crown cutting, crown cutting line is located in the enamel cementum boundary root 1-2mm square, take out the crown; Dressing section: the root section of the tooth was repaired with ultrasonic orthopedic knife 3mm below the alveolar bone, and the pulp of the crown was removed by a turbine (assisted with spraying of normal saline). Debridement: Removal of distal inflammatory tissue of the second molar; Suture: no tension suture, try to close the wound; Postoperative medication: Oral anti-inflammatory drugs (metronidazole, cefuroxime) for three days, if the postoperative reaction is serious, intravenous anti-inflammatory treatment. The surgical process of coronectomy: bone removal with turbine and root section trimming, and other operations are the same as minimally invasive coronectomy.

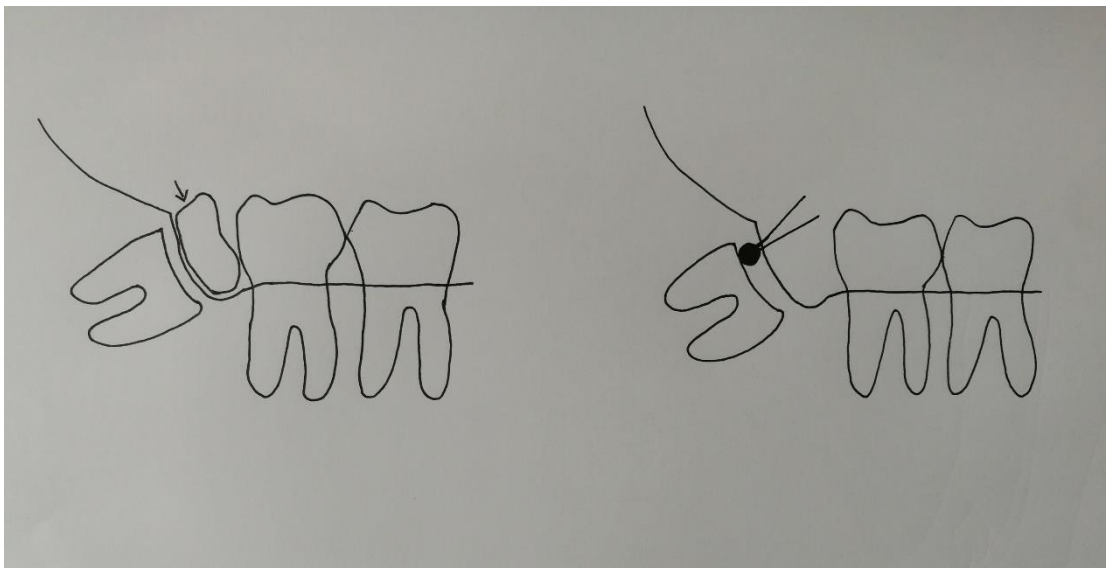

Fig. 1. The procedure of minimally invasive coronectomy

1.3 Observe items and evaluation criteria

1.3.1 Operation time: from the start of flap incision to the end of suture.

1.3.2 Intraoperative complications: intraoperative bleeding, adjacent tooth injury, root loosening, mandible fracture, temporomandibular joint injury.

1.3.3 Postoperative bleeding: One day after surgery, the patients were observed to see whether there was adverse blood clot or obvious bleeding in the tooth extraction wound.

1.3.4 Nerve injury: Injury of inferior alveolar nerve and lingual nerve.

1.3.5 Pain: The patients' cheek pain was classified as "no/mild pain" and "moderate/severe pain" after 1, 3 and 7 days of surgery to visit or telephone visit.

1.3.6 Swelling: The cheek swelling of the patients was classified as "no/mild swelling" and "moderate/severe swelling" after 1, 3 and 7 days of surgery in the visit or telephone visit.

1.3.7 Limitation of open mouth: after 1, 3, and 7 days of surgery, the patients were followed up by telephone, mouth opening degree was I° (mild mouth opening limitation), mouth opening degree was 2.0-2.5cm, mouth opening degree was moderate ° (moderate mouth opening limitation), mouth opening degree was mild ° (severe mouth opening limitation), mouth opening degree was mild ° (moderate mouth opening limitation), mouth opening degree was mild ° (severe mouth opening limitation), mouth opening degree was < 1.0cm.

1.3.8 Dry socket: From 2-3 days after the surgery, the patient experienced persistent severe pain at the tooth extraction

wound, which radiated to the auriculotemporal region, the back of the mandible and the top of the head. The pain could not be relieved by general analgesic drugs.

1.3.9 Subcutaneous emphysema.

1.3.10. Characteristics of postoperative root displacement

To study the characteristics of root displacement (protrusion direction, distance, etc.) in the six months after the minimally invasive crown-clipping and coronectomy. Root displacement distance measurement (Figure 2) : the distance (mm) from the midpoint of the root tip to the intersection point of the long axis and the mandibular occlusal plane on the curved section before and half a year after surgery was measured. The subtraction of the two part was the root displacement distance. In formula: root displacement distance = preoperative distance - postoperative distance.

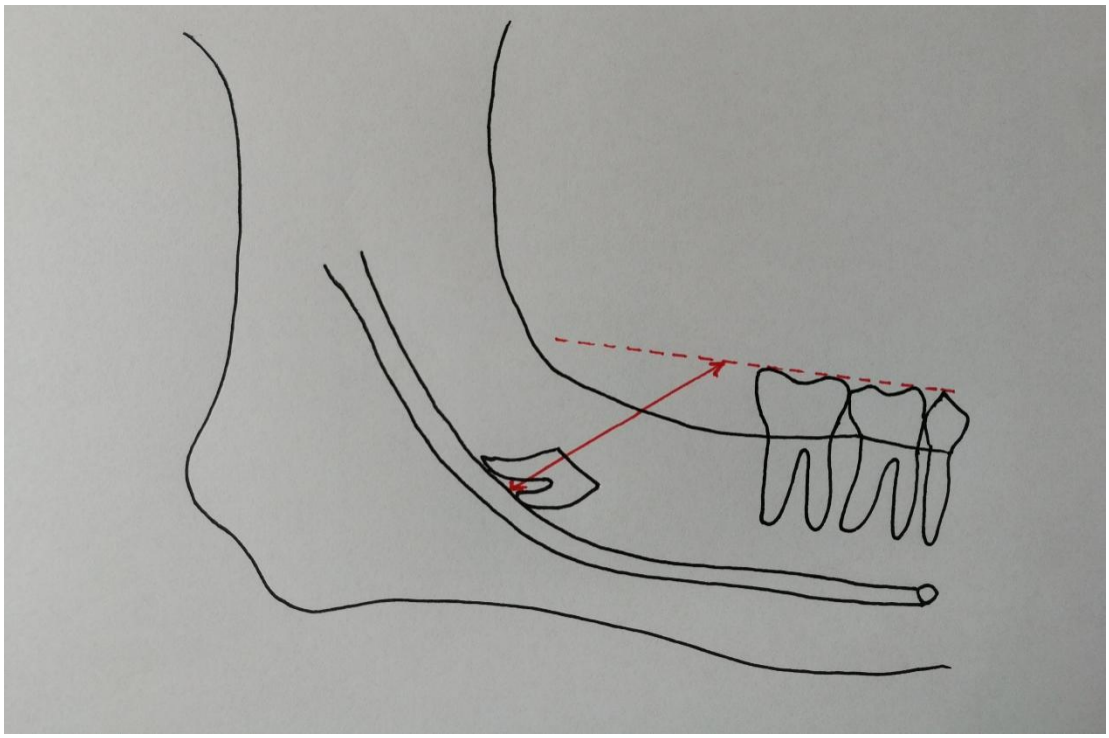

Figure 2: Measurement of root displacement distance

1.4 Statistical Methods

SPSS20.0 software was used to carry out T test and Chi-square test for data, P≤ 0.05 was statistically significant.

二. Restults

2.1 There was no significant difference in the operative time between the minimally invasive crown-amputation group (12.00±3.27) min and the coronectomy group (10.98±3.43) min (P = 0.254> 0.05). Roots in both the minimally invasive coronectomy group and the coronectomy group were moved forward and upward. The mean displacement distance of root in this two groups were 2.58mm and 2.62mm.Respectively, and there was no significant difference in the displacement distance between the two groups (P = 0.832> 0.05).

Tab.1 The comparison of postoperative complications of the two groups

Groups	blooding	Nerve damage	Moderate/ severe pain	Moderate/ severe swelling	Moderate/ severe mouth opening limitation	dry socket	Subcutaneous emphysema
Minimally invasive coronectomy group (30 cases)	0	0	0	1	2	0	0
Coronectomy group (30cases)	2	0	4	8	9	0	0
χ^2	0.517		2.411	4.706	4.007		
P	0.472		0.121	0.030	0.045		

2.2 No intraoperative complications. The incidence of postoperative hemorrhage, nerve injury, moderate severe pain, dry socket syndrome, and subcutaneous emphysema in the minimally invasive coronectomy group was not significantly different from that in the coronectomy group ($P > 0.05$), but the incidence of moderate severe postoperative swelling ($P=0.030$) and moderate severe mouth opening restriction ($P=0.045$) were lower than those in the coronectomy group ($P < 0.05$). (Form 1)

3. Typical case 1: Figure 3-8

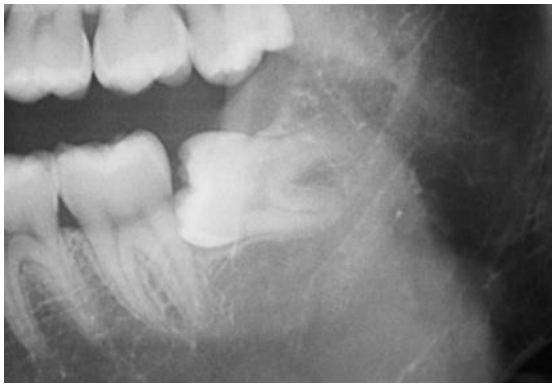

Fig. 3. Preoperative curved section

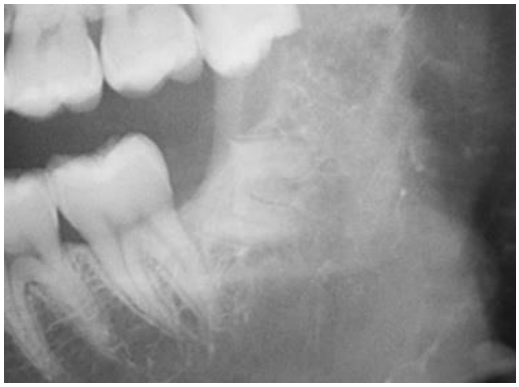

Fig4. Half a year after operation,Curved section, root detachment from neural tube

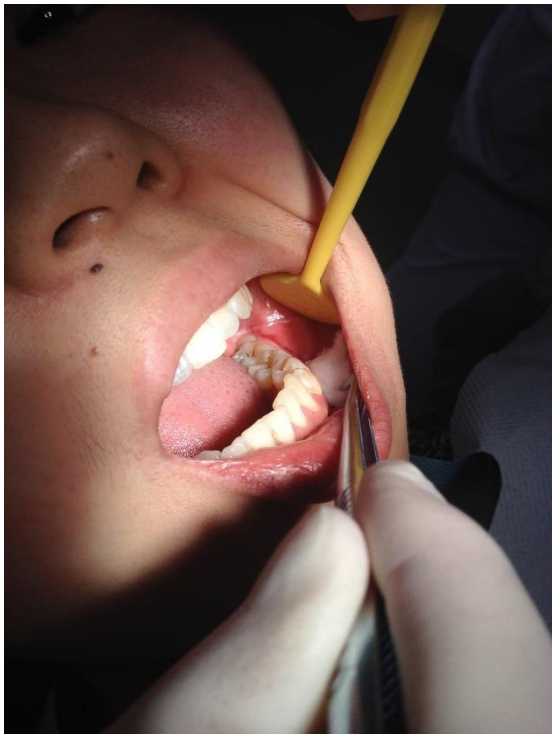

Figure 5. Preoperative intraoral photos

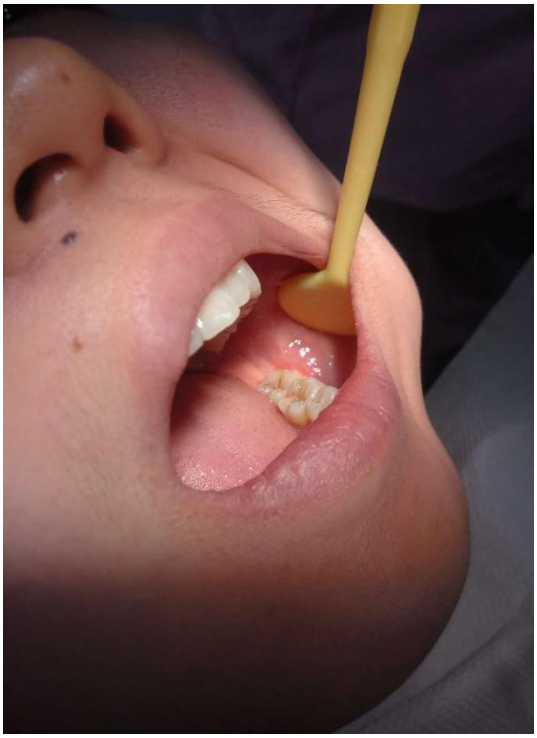

Figure 6. Oral photos after half a year surgery

Fig. 7. Coronal crown after coronectomy

Fig. 8. Second operation for root extraction

Typical case 2: Figure 9-15

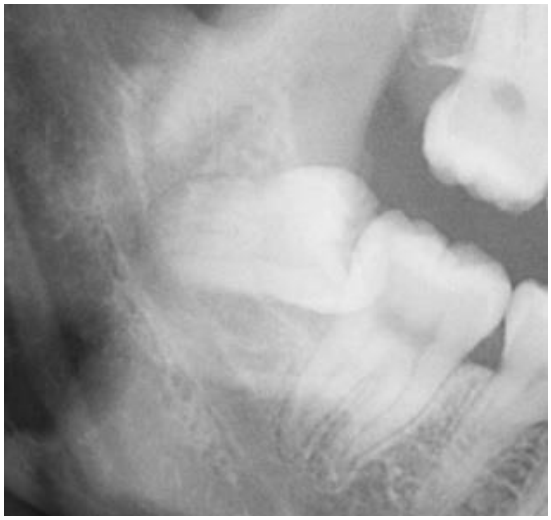

Fig. 9. Preoperative curved section

Fig. 10. Curved section half a year after operation. Root detached from neural tube

Fig. 11. Preoperative intraoral photograph

Fig. 12. Intraoperative intraoral photograph

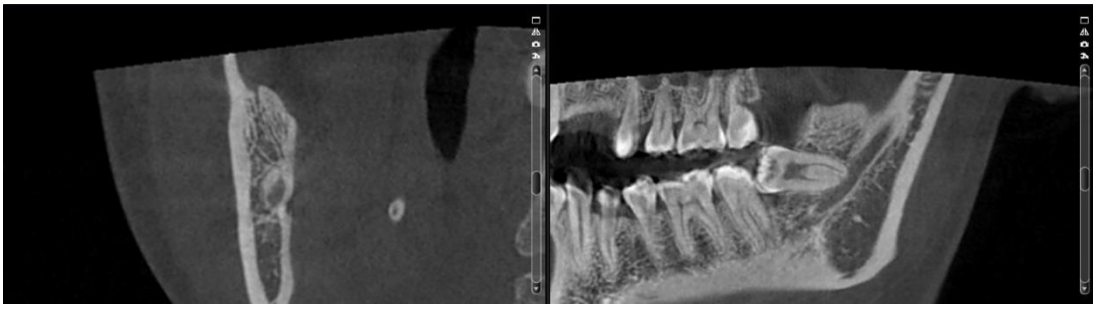

Fig. 13. Preoperative CT image,apical pressure on the alveolar neural tube

Fig. 14. Coronal crown after coronectomy

Fig. 15. Removal of the root by the second operation

四. Discussion:

The removal of the impacted mandibular third molar is one of the most common operations in the oral and maxillofacial surgery department. Due to the special anatomical relationship between the root of the impacted mandibular third molar and the inferior alveolar neural tube, it is common to contact and press the alveolar neural tube under the root of the impacted mandibular third molar. Complications such as IANI often occur during the extraction. Therefore, some scholars [6-7-8] adopted the method of coronectomy to avoid the occurrence of IANI. The incidence of complications such as bleeding, infection, pain and dry socket disease after crowning and root removal was similar to that after third molar extraction. Except for O 'Riordan [9], who once reported 1 case of postoperative bleeding, other scholars did not report any bleeding. In this study, there were two cases of postoperative bleeding in the coronectomy group, and the bleeding stopped after compression and oral hemostasis on the second day after surgery. The cause of hemorrhage may be related to the proximal middle incision across the vestibular sulcus and more bone removal by turbine. Four patients in the clipping group had postoperative pain in the coronectomy group, which may be related to more bone removal by turbine and greater trauma. No pulp pain occurred in the two groups.

In previous studies, IANI was less likely to be occurred after coronectomy. Pogrol et al. [8] adopted coronectomy method in 50 cases of affected teeth, and there was no occurrence of IANI after surgery. Leung et al. [10] found that only 1 case (0.05%) of IANI occurred in the group of coronectomy group, while 9 cases (5%) of tooth extraction group had IANI. Hatano et al. [11] reported that only 1 case (1%) of postoperative functional paralysis occurred in the coronectomy group, and it improved within 1 month. IANI occurred in 6 cases (5%) of the tooth extraction group, and 3 cases had long-term damage. Renton et al. [6] found that no IANI was found in the successful coronectomy group, 3/36 (3%) cases of IANI occurred in the failed group, and 19/102 (19%) cases of tooth extraction group. O 'Riordan et al. [9] reported 3 cases of short-term postoperative injury and recovered within 1 week. As for postoperative lingual nerve injury, only one case of lingual paresthesia 5 days after coronectomy was reported by Pogrel[8], which was considered as intraoperative TCM induced lingual nerve injury. There was no occurrence of IANI in the two groups in this study.

In 1880, Marie and Jean discovered that the piezoelectric effect could make objects deform and produce ultrasonic vibrations. Tomaso Vercellotti, an Italian oral surgeon, used this principle to cut bone and created the

piezosurgery. piezosurgery makes use of the "hole effect" to amplify vibration and transfer it to the ultrasonic working tip, and the working tip puts a little pressure on the bone surface, that is, mechanical cutting on the bone surface [12]. piezosurgery is composed of main machine, ultrasonic working point and foot control. The ultrasonic working point is composed of different shapes, sizes and materials. Different working points adapt to different bone cutting requirements. The vibration frequency (25~30 kHz), amplitude (60~210 μm) and water velocity of the working point are controlled by the main machine. When the frequency exceeds 30 kHz, the host machine automatically stops working to avoid excessive pressure and local overheating on the bone surface, thus minimizing the injury [13]. Ultrasonic bone knife has the following three characteristics: 1. High accuracy, small trauma. The amplitude of ultrasonic bone cutter working tip in horizontal direction is 40-200 μm and in vertical direction is 15-60 μm. Therefore, the operator has no obvious feeling of vibration during operation, the operation is light and controllable, and the effective cutting can be carried out by mild pressure, so as to avoid excessive force leading to slip-off of the working point and injuring adjacent tissues, thus improving the accuracy and safety of the operation [13]. The ultrasonic bone knife adopts cold cutting mode during cutting, and the working point temperature is generally controlled below 38℃ to avoid excessive heat generation affecting the healing of bone tissue [12]. Berengo et al. [14] studied the influence of different surgical tools on the survival rate of osteoblasts and osteocytes around bone blocks, and found that the use of piezosurgery and bone forcers to remove bone had minimal damage to bone blocks. Li Dan et al. [15] applied piezosurgery for bone removal and space expansion in maxillary pulp death and split tooth extraction, and found that the piezosurgery group could better preserve the bone volume of alveolar bone and reduce bone trauma. Song Yong et al. [16] recommended the application of piezosurgery to remove impacted teeth in the middle, low and near middle or horizontal, in order to reduce postoperative trauma and improve surgical efficacy. Fan Zhen [17] and Wang Liping [18] et al. carried out internal maxillary sinus lifting by using piezosurgery, which effectively reduced the perforation rate of the mucosa of the maxillary sinus floor. 2 Selective bone cutting. piezosurgery is selective in cutting hard and soft tissue. Its vibration frequency only has a cutting effect on hard tissue, but does not have a cutting effect on soft group [19]. Therefore, piezosurgery has special advantages in surgery adjacent to important soft tissue structures [20, 21, 22]. 3. Less bleeding and clear surgical field. piezosurgery produces cavitation during cutting and less bleeding on the bone surface. Combined with the cooling system to remove bone debris and blood, the operative field is clear. Because the piezosurgery only cuts hard tissue and has no cutting effect on soft tissue, the bleeding caused by soft tissue injury can be avoided [12].

Although piezosurgery has many advantages, it still has limitations such as low cutting efficiency, high equipment cost and easy wear of working point [23]. Therefore, many scholars adopt the combined application of piezosurgery and traditional equipment to make full use of their strengths and circumvents weaknesses and give play to their respective advantages. Zhang Zhuo [24] with high speed turbine with piezosurgery treatment such as drill out joint mandibular impacted wisdom teeth, found that the piezosurgery group and the joint operation time significantly shorter than the turbine group, intraoperative blood loss joint group was obviously less than the other two groups, postoperative pain, swelling and limited mouth opening degree were significantly lighter than the other two groups, surgical complications joint group was obviously less than the other two groups. Liu Zhaoyang [25] et al. used the combined program of piezosurgery and 45° inverse Angle turbo drill to remove complex impacted mandibular wisdom teeth, which showed significant curative effect, effectively shortening tooth extraction time and reducing intraoperative

blood loss. Due to the high speed turbine water pipeline disinfection difficult, surgical trauma is bigger, but cutting tooth hard tissue of high efficiency and cutting tooth hard tissue piezosurgery treatment efficiency is low, but high precision cutting bone tissue, small trauma, less bleeding, so this study minimally invasive cut crown group (spray with physiological saline) using high speed turbine sections, except for the crown pulp grinding, piezosurgery osteotome boneless, shaping root cross section, It is minimally invasive and saves time. Through the study, we found that no IANI occurred in the two groups after coronectomy. The postoperative complications (swelling and mouth opening limitation) in the minimally invasive coronectomy group were much lower than those in the coronectomy group, and no additional operation time was added.

Whether the root can be retained in the alveolar bone for a long time after coronectomy, the possible problems (root displacement, apical inflammation, apical cyst, etc.), the choice of indications, and the risks in the operation process, etc., restrict the extensive clinical development of coronectomy, and there have been debates [26].

A large number of previous studies have shown that long - term root displacement is inevitable after coronectomy. Long et al. [7] systematically studied 4 articles on coronectomy reported from January 1990 to October 2011, and found that the root shifted away from the neural tube after surgery, with a displacement rate of 13.2%-85.29% and a movement distance of 3.06± 1.67mm. Dolanmaz et al. [27] studied 47 patients with coronectomy and found that the root displacement was 3.4mm at 6 months, 3.8mm at 12 months and 4.0mm at 24 months after surgery. Leung et al. [10] observed 135 cases of coronectomy for 3 years, no postoperative IANI occurred, 4 cases (3%) had root eruption and extraction, and the root displacement was most obvious in the first 12 months and stopped 24 months later, with an average displacement of (2.8±1.4) mm. Domestic scholar Zhu Yuaguang et al. [28] found that all 22 cases of coronectomy techniques had tooth roots shifted upward and away from the inferior alveolar neural tube, and the risk of IANI was significantly reduced. 12 months after the operation, 7 cases of vertical impacted teeth moved 3mm toward the alveolar ridge, 3 cases of vertical impacted teeth were exposed in the oral cavity, 6 cases of mesial impacted teeth moved 2mm toward the alveolar ridge, and 6 cases of mesial impacted teeth were exposed in the oral cavity. In the observation of the 168 cases 3 years after the operation, they [29] found that none of the 168 cases had IANI, and the root displacement occurred within 24 months after the operation, and no root displacement occurred from 25 to 36 months after the operation. The mean postoperative root displacement was 1.1mm at 6 months, 2.6mm at 12 months, 2.9mm at 24 months, and 2.8mm at 36 months. In this study, it was found that the root of the minimally invasive coronectomy group and the coronectomy group both shifted forward and upward 6 months after surgery, with an average displacement distance of 2.58mm and 2.62mm, respectively. In the process of tooth extraction, if the cut root is less than 5mm and has no obvious lesions in the peri-root tissue, and the continued root removal is too traumatic, or may cause nerve damage, maxillary sinus perforation and other complications, it can be considered not to remove the root and pay attention to observation [30]. Hu Kaijin et al. [31] believed that roots with a size smaller than 3mm were free of inflammation and should not be treated, while roots larger than 3mm should be removed. According to domestic scholars [32], the indications for residual roots in the extraction of mandibular impacted third molars are roots smaller than 3mm, roots without pulp infection, and roots and mandibular canal as the third type of contacts. In the pre-experiment phase of this study, one patient was observed to have apical shadow two years after crown amputation, which may be related to the root moving up and exposed in the oral cavity (Figure 16-18). No apical shadow was observed in the other cases.

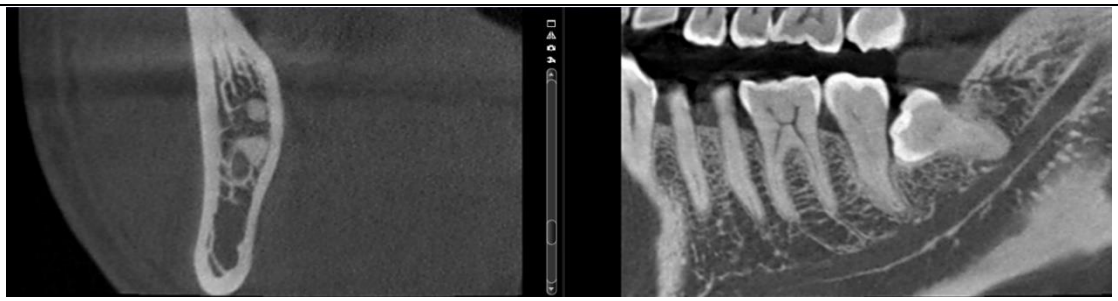

Figure 16. Preoperative root compression of the neural tube.

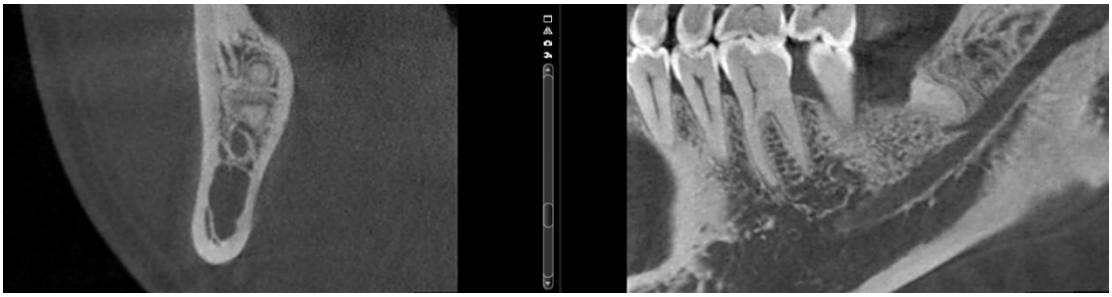

Figure 17. Six months after the operation, the root of the tooth shifted forward and detached from the neural tube. The patient requested postponement of the second operation.

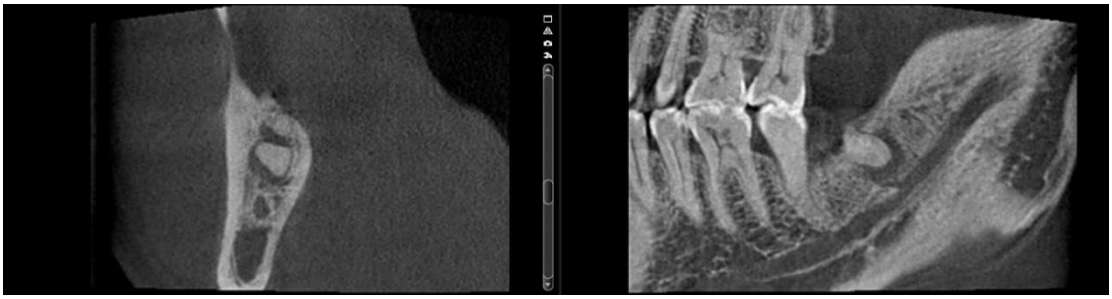

Fig. 18. Two years after the operation, the patient had no obvious self-conscious symptoms. The root section was exposed in the oral cavity and the root tip was Shadowed.

In our study, we used minimally invasive coronectomy with piezosurgery.Postoperative complications (swelling and mouth opening limitation) were significantly reduced in patients, and IANI was not found in all cases. We made full use of the inevitable displacement of the root after surgery, and imaging examination was performed half a year after surgery. All the roots were moved forward and upward and separated from the inferior alveolar neural tube, and the roots were removed in the second operation, effectively solving the problems caused by long-term retention of the root. Domestic scholars have started to use the method of division by crown and root, and achieved good results [33]. Therefore, for the mandibular third molars with high risk factors such as root extraction and contact or compression between the lower alveolar neural tube, minimally invasive crowning and root retention with piezosurgery is a good alternative, which is worthy of clinical promotion.

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